

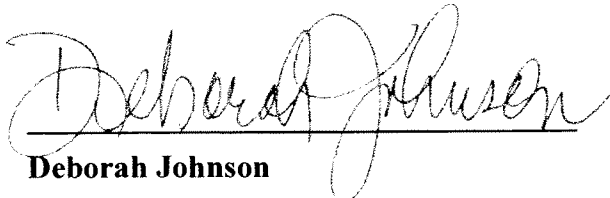


# **Federal Aviation Administration**

Final  
Fully Releasable  
Version 5.1  
September 2008

## **An Operational Concept for NextGen Towers**

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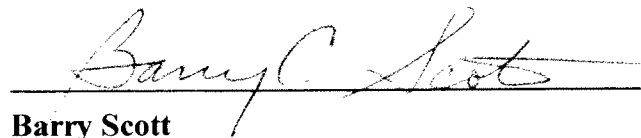
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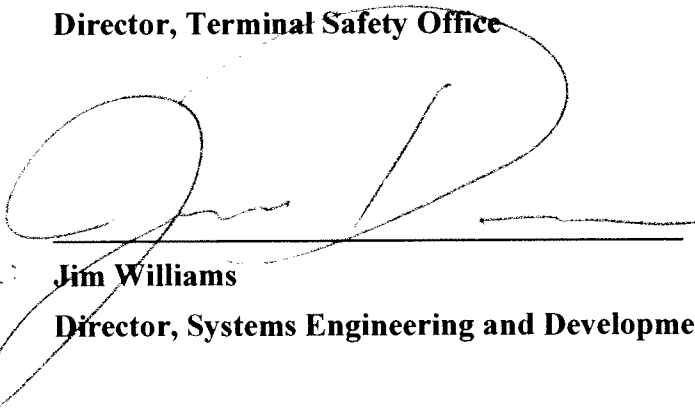
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## Revisions

Rev. No.	Date	Comments
4.0	August 11, 2008	Initial version.
4.1	September 8, 2008	Responded to initial comments on Draft version 4.0. Comment matrices in separate documents.
5.0	September 15, 2008	Made additional changes to document which include a re-writing of the Executive Summary; addition of a Forward; re-writing Section 4.0 to ensure it is less solution focused; and deletion of Appendix A, Alternatives Systems for Surface Surveillance.
5.1	September 19, 2008	Made additional edits to document.

## **Abstract**

The Joint Planning and Development Office (JPDO), established by the White House in 2003, has over the past several years developed the Next Generation Air Transportation System (NextGen)—a concept of the air traffic system for the future. The NextGen envisions a ground-level facility, fully automated or staffed, from where services will be provided for air traffic in and out of one or more remote airports. This document presents concepts of operations for both types of NextGen Towers. It describes the basic elements of the NextGen Tower Concepts. For Staffed NextGen Towers this includes an integrated display system for presenting surveillance and other information to the controllers, a suite of decision support tools (DSTs) and the use of aircraft-derived data when available. For Automated NextGen Towers this includes an automation system that will provide synchronization capability and issue appropriate clearances and voice recognition technology for processing pilot requests and for evaluating pilot read-backs. An initial transition strategy for moving towards the NextGen Towers via an incremental introduction of various technologies is also described.

**KEYWORDS:** JPDO, NextGen, Automated NextGen Towers (ANT), Staffed NextGen Towers (SNT), Remote Tower, Aircraft-derived Data (ADD), Decision Support Tools (DSTs)

## **Foreword**

The air traffic in the United States (U.S.) is expected to increase significantly over the next several decades. Some high-end estimates indicate that by the year 2025 the total passenger enplanements may more than double and total aircraft operations may triple in comparison to the traffic today. In the next 10-15 years, most US tower facilities will reach the end of their useful life. The cost of new tower construction is escalating and is rapidly reaching a point where requirements are exceeding budgets. The FAA has to develop new operational concepts to increase capacity and address the predicted growth in airport tower operations while still addressing the cost prohibitive nature of replacing air traffic control towers with new towers. This document introduces a preliminary operational concept for the Next Generation Air Transportation System (NextGen) towers needed to meet these future traffic demands while improving operational efficiency and enabling cost-effective expansion of air traffic services to a significantly larger number of airports than possible with traditional methods of service delivery.

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## Executive Summary

As the number of flights and passengers increase and as the technology ages, the Federal Aviation Administration (FAA) must develop new systems to support the National Airspace System (NAS). In the Next Generation Air Transportation System (NextGen) Concept of Operations, version 2.0, the Joint Planning and Development Office (2007) outlines the plan for the future, including a number of new technologies and operating methods such as System Wide Information Management, digital data communications, four-dimensional trajectory planning, and NextGen Towers (NT). The FAA must conduct a considerable amount of research and development to implement these NextGen concepts.

To meet the predicted demand in airport tower operations, the classical method for increasing airport capacity would require building additional runways at the towered airports and building towers at the non-towered airports. Adding runways at a towered airport may sometimes require building an additional tower to address line of sight issues (i.e., the new runways may not be visible from the existing tower). To exacerbate the capacity issue, many of the existing tower facilities have reached or are reaching the end of their functional life-cycle and need to be replaced or significantly refurbished. The cost of building a new tower however is rapidly escalating and is becoming prohibitive.

The NT concept reduces the need for physical infrastructure associated with Airport Traffic Control Towers (ATCTs) and will provide a means to control airport traffic from a ground level location. The functional capabilities of the future NextGen facilities and the services provided from these facilities will vary widely according to the volume and complexity of traffic at the individual airports that are being served. The 35 Operational Evolution Partnership (OEP) airports exhibit high volume and complexity of air traffic and the aircraft operating in and out of these airports generally are equipped with high-end avionics such as Mode-S transponder and data link. However, a majority of airports exhibit low volume and complexity of traffic, have minimal Instrument Flight Rules (IFR) traffic and are used almost exclusively by general aviation (GA) aircraft that are unlikely to be equipped with advanced avionics.

Two types of NextGen Towers are considered. In Staffed NextGen Tower (SNT), Air Navigation Service Provider (ANSP) personnel will provide full air traffic management (ATM) services from a ground level facility to flights in and out of one or more airports. The ANSP personnel will be assisted by an integrated tower information display that presents weather, surveillance data and other essential information and suite of decision support tools (DSTs). When available the DSTs will use aircraft derived data (ADD) obtained from aircraft. In an Automated NextGen Tower (ANT), the ground level facility will be fully automated and a limited number of basic ATM services will be provided without any human participation. The automation system will make use of available data (e.g., traffic demand, surveillance and weather) and generate appropriate sequences, clearances and advisories that will be transmitted via synthetic voice and/or data link to the aircraft. These facilities will generally be implemented for presently non-towered low-end airports and may also provide services during non-peak hours to airports that are normally served by a staffed facility.

The operational concept of SNT presented in this document focuses on the ability to provide ATM surface management by leveraging new technologies to replace direct visual observation of runway operation. In lieu of the out-the-window (OTW) view the concept provides alternative target acquisition methods to be used for various ATM functions such as issuing clearances, alerting of runway obstructions, and providing separation assurance. The ANSP personnel will use a large and clear integrated 2-D display(s) that presents surveillance and weather data to the controllers; it will present the position, velocity and other data on aircraft and other vehicles as they move on the airport surface. This alternative method for providing for target acquisition relies on some type of surveillance information and will allow for precise positioning of aircraft at night and in inclement weather conditions when the aircraft would be beyond the visual range of the ANSP personnel in a conventional tower cab. The surveillance infrastructure at large airports may already support this once certified for separation whereas a business case would need to be developed for medium and smaller airports. As the density and complexity of traffic at the airport increase, ANSP personnel will also use a suite of Decision Support Tools (DSTs) that will incorporate aircraft-derived data when available.

The operational concept of ANT presented in this document offers an innovative way to affordably provide new services where service delivery was not practical before. The ANT automation system will provide synchronization capability and issue appropriate clearances. Voice recognition technology will be used for processing pilot requests and for evaluating pilot read-backs. Digital voice systems will be used for delivery of clearances and data link transmission may be used for equipped aircraft. The weather information and flight planning assistance will continue to be provided as now from Automated Flight Service Station (AFSS), National Oceanic and Atmospheric Administration (NOAA) and commercial vendors; however, all weather information will be integrated according to the NextGen Network Enabled Weather (NNEW) concept.

This document further expands and develops the NT concept as a first step in the process to determine its operational feasibility. The concept depicted in this document will be used as a foundation for future analyses (e.g., functional, technical, safety). Initial areas for further research and development efforts needed for the NT are highlighted.

**Conclusion:** The NextGen towers concept provides a means for the FAA to address predicted future demand and cost-effectively expand air traffic services at the same time. This report details the NT concepts of operations that may then serve as the foundational structure for future research and development efforts needed to determine its operational feasibility.

# 1 Introduction

The Federal Aviation Administration (FAA) presently operates airport tower facilities at 503 airports. Of these, 264 airports have FAA Towers, that is, the Air Traffic Control (ATC<sup>1</sup>) services are provided by FAA controllers; the other 239 airports have Contract Towers that are staffed by contract controllers. There are also thousands of other non-towered airports where ATC services are provided without having a control tower at the airport. The traffic at these non-towered airports is generally low; however, there are a number of such airports that have traffic levels higher than those at many towered airports.

The air traffic in the United States (U.S.) is expected to increase significantly over the next several decades [1]. Some high-end estimates indicate that by the year 2025 the total passenger enplanements may more than double and total aircraft operations may triple in comparison to the traffic today. In response to this daunting challenge, the Joint Planning and Development Office (JPDO) developed the Next Generation Air Transportation System (NextGen) concept. It will permit meeting these future traffic demands without increasing traffic delays and air traffic service delivery costs to unacceptable levels. NextGen will also improve operational efficiency, extend hours of operation and generally extend access to the National Airspace System (NAS).

NextGen plans to address the airport capacity problem by increasing the capacity of high-density hub airports and by improving services at the satellite airports and presently non-towered airports. To meet these objectives, an alternative, more flexible method for providing tower services is required. The alternative method must provide for target acquisition when the out the window (OTW) view exceeds human effectiveness (e.g., at night and in inclement weather), and when precise positioning of aircraft is beyond controller visual ranges. Enhancing the ability to provide ATC services will thus improve capacity by overcoming some of these existing capacity constraints.

The classical method of increasing capacity would mean building additional runways at the towered airports and building towers at the non-towered airports. Adding runways at a towered airport sometimes requires building an additional tower because the new runways may not be visible from the existing tower. The cost of building a new tower however is rapidly escalating and is becoming prohibitive. Many of the existing tower facilities have reached or are reaching the end of their functional life-cycle and need to be replaced or significantly refurbished. The present FAA budgets do not fully support the capital expenditures necessary for construction of new towers while sustaining the present facility infrastructure.

The NextGen concept; therefore, envisions a ground-level facility from which Air Traffic Management (ATM) services will be provided to operations in and out of one or more airports.

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<sup>1</sup> Currently FAA personnel at the Air Route Traffic Control Center (ARTCC), Terminal Radar Approach Control (TRACON) and Airport Traffic Control Tower (ATCT) are responsible for the *control* of air traffic. NextGen envisions that in the future, FAA personnel will be responsible for the *management* of air traffic, and that there will be a paradigm shift from air traffic control (ATC) to air traffic management (ATM). Consequently, the term ATC is used in the context of present operations whereas the term ATM is used in the context of future NextGen operations.

Such a facility may be away from the airports being served and is sometimes referred to in literature as a *Remote Tower*. The term is a misnomer because there is no tower but a ground-level facility. NextGen also envisions an overall reduction of the total service delivery points (SDPs) resulting in a reduction of the overall cost of providing ATC services.

A number of new technologies such as integrated tower controller displays, decision support tools (DSTs) and use of ADD obtained via data link are expected to be introduced in the NAS to support NextGen operations. Application of these technologies at the presently towered airports will increase their capacity under Instrument Meteorological Conditions (IMC) and generally improve the flexibility and efficiency of their operations. These technologies will also support the concept of NextGen Towers, that is, the concept of providing ATC services from remote ground-level facilities. The basic elements of the NextGen tower technology may also extend the range and accuracy of human visual surveillance that, in turn, may improve the quality of ATM services.

If the airport services can be provided from remote ground level NextGen facilities, FAA would be able to avoid the future costs for construction of new and refurbishment of existing airport tower facilities. Additionally, because the ground facility need not be physically associated with the airport, it is conceptually feasible that the air traffic controllers could service multiple airports, depending on the ebbs and flows of traffic.

The US airports exhibit a wide variation in volume and complexity of air traffic. The top 50 -70 airports that include all 35 Operational Evolution Partnership (OEP) airports exhibit high volume and complexity of air traffic. These airports generally have a peak of over 50 hourly operations, although some airports such as Hartsfield-Jackson Atlanta International Airport (ATL) and Chicago O'Hare International Airport (ORD) may have a peak of over 200 hourly operations. The aircraft operating in and out of these airports generally are equipped with high-end avionics such as Mode-S transponder and data link. However, a majority of airports exhibit low volume and complexity of traffic. Some may have a peak traffic density of only less than 5 operations per hour; these airports also have minimal Instrument Flight Rules (IFR) traffic and are used almost exclusively by general aviation (GA) aircraft that are unlikely to be equipped with advanced avionics such as Mode-S transponder, Automated Dependent Surveillance - Broadcast Mode (ADS-B) and Data Link.

Virtual Towers enable the cost-effective expansion of services to a significantly larger number of airports than is possible with traditional methods of service delivery. The functional capabilities of these NextGen facilities and the services provided from these facilities will vary widely according to the volume and complexity of traffic at the individual airports that are being served. Two basic types of NextGen Towers are envisioned here:

- *Staffed NextGen Tower (SNT)*: ATM personnel will provide full ATM services from this ground level facility to flights in and out of one or more airports. The ATM personnel will be assisted by an integrated tower information display that presents weather, surveillance, and other essential information, and a suite of DSTs. Such technologies will be leveraged to overcome the limiting factors (e.g., weather, darkness, visual range) that effect human visual acuity and the delivery of ATM services on the surface. When available, the DSTs will use ADD obtained from the aircraft.

- *Automated NextGen Tower (ANT)*: ANTs are an innovative way to provide new services in an affordable way where service delivery was not practical before. This ground level facility will be fully automated and a limited number of basic ATM services will be provided without any human participation. The automation system will make use of available data (e.g., traffic demand, surveillance and weather) and generate appropriate sequences, clearances and advisories that will then be transmitted to the aircraft. These facilities will generally be implemented for presently non-towered low-end airports, and also may provide services during non-peak hours to airports that are normally serviced by a staffed facility. The intent is to provide a better service for equipped aircraft than today's one-in-one-out service, while supporting non-equipped aircraft (e.g., via digital voice transmissions).

This report describes the operational concepts for both SNT and ANT facilities.

## **2 Assumptions Related to the NextGen Tower Concept**

The NextGen Tower Concept presented here is based on certain assumptions and capabilities on the part of airport, aircraft, Decision Support Tools (DSTs), policies and procedures, and the division of roles and responsibilities between ATM personnel, pilots, dispatchers, security personnel and airport operators. The major assumptions listed here represent the NextGen tower configuration for the Year 2017 and beyond; these assumptions may change as the NextGen technology development matures.

### **2.1 Assumptions Related to SNT Concept**

The major assumptions related to the SNT concept are:

- There will be a fundamental shift in the roles and responsibilities of the ATM service provider, aircraft/pilot, and flight operations center personnel. Presently the service provider has proportionately much larger influence on ATM decisions. Although the aircraft and the flight operations center share a lot of information between them, they share little information with the service provider. In the NextGen timeframe, these three entities will share all the information in a net-centric environment and influence, somewhat equally, the ATM decisions.
- Some form of secondary surface surveillance system is present at the airport. The status of all ground movement of aircraft and other vehicles is presented on a two-dimensional (2-D) display for ATM personnel. Such a display will also present the necessary weather information.
- All aircraft operating in and out of large SNT-serviced airports will be equipped with a transponder. A significant number of aircraft may also carry multi-functional flight deck display and data link equipment; these aircraft will be capable of providing ADD requested by the ATM system. However, the SNT concept will continue to accommodate aircraft unequipped with the multi-function display and those that cannot provide ADD. Aircraft without a transponder or with a failed transponder will be accommodated at large airports only under emergency conditions.
- It is expected that a significant majority of aircraft operating in and out of small airports will be equipped with a transponder; however, the SNT concept will accommodate aircraft that are not equipped with a transponder. This will be accomplished by having either some form of primary surveillance or visual surveillance using digital cameras or other available technologies.
- Airports will be required to implement perimeter security to minimize runway/taxiway incursion by animals, pedestrians and other non- authorized vehicles. Airports will also be required to minimize the presence of Foreign Objects and Debris (FOD) on runways and taxiways.
- Necessary DSTs will be available to ATM personnel for minimizing the capacity/demand imbalances, runway load balancing, and implementation of traffic management initiatives and for generally improving the airport operational efficiency.

- Airports will be certified for SNT service, aircraft will be certified for operating in and out of SNT-serviced airports, and ATM personnel will be certified for providing services at these airports.
- The envisioned integrated tower display for presenting weather and traffic has been certified for use by ATM personnel for providing separation services in absence of the view from the cab window.

## 2.2 Assumptions Related to ANT Concept

The major assumptions related to the ANT concept are:

- There is a secondary surveillance system that monitors the movement of equipped aircraft on the airport surface and in the surrounding airspace.
- The ANT airport has a separate communications frequency assigned to it.<sup>2</sup>
- ANT must accommodate a significant population of unequipped aircraft in providing the Sequencing service in and out of the airport. Consequently, FAA must ensure that either there is sufficient coverage from one or more distant primary surveillance radar or that all aircraft are mandated to carry a transponder and/or ADS-B Out system. FAA may choose to pay for equipping these aircraft with appropriate avionics.
- If ANT is providing Separation service in surrounding airspace, ANT automation system has the capability to generate and transmit (via digital voice or data link for equipped aircraft) appropriate alerts to the pilots.
- If ANT is providing Separation service on the airport surface, there is either primary surface surveillance or there are other surface sensors for detecting unequipped aircraft and vehicles on the airport surface.
- ANT automation will not provide runway obstruction alerts.
- Airports will be required to implement perimeter security to minimize runway/taxiway incursion by animals, pedestrians and other non- authorized vehicles. Airports will also be required to minimize the presence of FOD on runways and taxiways.<sup>3</sup>
- Airports will be certified for ANT service and aircraft/pilots will be certified for operations in and out of these airports.

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<sup>2</sup> There will be such a frequency if the airport had a control tower before it was converted to an ANT airport. If not, assigning a new frequency to a presently non-towered airport may worsen the spectrum congestion problems.

<sup>3</sup> Authorized ground vehicles will carry a transponder or ADS-B. Presently enhanced vision and other technology solutions are available for perimeter security and FOD detection.

### **3 Situational Awareness in a Staffed NextGen Tower (SNT)**

The basic SNT concept envisions the capability to provide ATM services to traffic in and out of an airport without the need for ATM personnel to be in a control tower at the airport. In essence, the services are provided from a ground-level facility away from the airport. The ATM personnel in such a facility do not have an OTW view from the tower cab. They must develop a sufficiently full situational awareness with the help of advanced information displays and the use of advanced DSTs for providing air traffic services to the aircraft.

#### **3.1 Present Use of the Out-the-Window (OTW) View**

A tower controller typically uses his/her eyes and ears to maintain situational awareness as it relates to surface operations, arrivals and departures and operations in the vicinity of the airport. In fact, this is so important and critical to the safety and efficiency of airport operations that the rules [2] require the Local controllers to visually scan runways to the maximum extent possible and the Ground controllers to assist the Local controllers in visually scanning runways, especially when runways are in close proximity to other movement areas. International Civil Aviation Organization (ICAO) and European documents also require these controllers to visually scan runways and movement areas.

Visual surveillance undoubtedly leads to quick response during emergencies. When, for example, Flight AF358 skidded on landing and caught fire on 2 August 2005 in Toronto, Canada, visual surveillance through the tower window resulted in early detection of the accident. The emergency teams were at the site in less than a minute and the crew and all passengers were evacuated in about two minutes [3]. Such a quick response may not have been possible without some form of a visual surveillance capability.

Air traffic controllers consider direct, visual surveillance through the cab window as an indispensable element of achieving a full situational awareness as it relates to the tower operation [4]. In addition to looking out the windows, controllers also look at various radar weather displays and flight strip information to confirm their visual surveillance. Although they may spend a considerable amount of heads-down time, they consider visual surveillance as their primary means of surveillance. Even when they are looking at heads-down displays, they usually verify visually through the window and confirm supplemental information including conformance with ATC clearances and instructions.

There are a number of ATC activities that require visual surveillance by ATC personnel. These include, for example:

- Observing changing weather between manual and automated weather updates
- Scanning runways, airport ground and apron areas for ground vehicles, support equipment, aircraft parts, baggage, animals, birds and other FOD
- Scanning for emergencies on runways such as engine fire or smoking, blown tires, skidding aircraft, and other malfunctions that may affect the airport and aircraft operations
- Monitoring conformance with ATC clearances and instructions to prevent runway incursion situations

The OTW view is, however, of limited use during night and other low visibility operations. Recent studies [4] have shown that during periods of heavy traffic ATM personnel depend less on the OTW view and more on the heads-down displays and supplemental control instructions.

### **3.2 Substituting for the Window View**

In a remote ground-level NextGen facility there will be no tower cab and no OTW view. Consequently, ATM personnel must be provided with an alternative means of obtaining the information they depend on and get from the OTW view. Some form of secondary surface surveillance can provide aircraft locations and their velocities as well as the status of apron and movement areas and runways. Consequently, such surveillance can help the controller to determine aircraft conformance with ATM instructions. However, such surveillance may be of minimal use with aircraft emergencies and with unequipped aircraft. Information on a number of emergencies related to aircraft can be obtained from the aircraft itself; this may require aircraft to be equipped with a form of data link capability, although presumably such information can be sent via voice. If there is a significant population of aircraft that cannot provide ADD, and if one must accommodate aircraft without any transponder, there must be some method of primary (non-cooperative) surveillance or visual surveillance for the terminal area and for the airport surface. Use of digital cameras has been examined for providing such visual surveillance. However, it is not clear at this time if such cameras can provide sufficient fidelity and update rate for use at the airports with high volume and complexity of traffic. Consequently, various options for substituting the window view must be examined in detail in laboratory and operational tests before determining an acceptable NextGen Tower configuration for implementation. It is expected that the choice of an appropriate combination of alternative surveillance systems (primary, secondary, and visual) will be site-specific.

The concept of such a NextGen tower represents a paradigm shift and will require a fundamental change of the present ATM culture. In addition, changes in policy and procedures will require a partnership between the service provider, aircraft operators, and airport operators. Some roles and responsibilities of the ATC personnel may have to be shifted to airport and/or aircraft operator personnel located at the airport. The level and the extent of such changes will depend on the surveillance infrastructure at the airport, ATM automation system capabilities, capabilities of the aircraft operating in and out of the airport, and volume and complexity of the traffic at the airport being served.

There are potentially a number of different options for substituting OTW view. For example, relevant weather can be displayed on the SNT display and the time period between weather updates can be reduced. Also, digital cameras may be used to scan the weather between updates; FAA is examining such a use under the Alaska Weather Camera Program. Digital cameras can also be used to scan runways and taxiways or airport authorities may implement sensors for scanning these areas. Although present cameras may not provide sufficient fidelity and update rates for use at high-end airports, they may be quite suitable for low and medium traffic airports. Also, performance of digital cameras would continue to improve in the future. The aircraft may also be able to provide emergency-related aircraft status information to SNT automation. Such ADD may assist controllers in identifying emergencies on runways and taxiways; however, all aircraft will not be equipped to provide ADD. Also some aircraft may not

have onboard sensors to detect certain events such as wheel assembly fire and tire blowout; therefore, it is possible that certain responsibility for handling emergencies may have to be shared between service provider and airport/aircraft operators.

It must be noted here that all the above options for substituting OTW view must be validated by rigorous safety analysis and extended laboratory and operational trials; only then can these options be considered as feasible.

## 4 Operational Concept for an SNT Facility

The SNT operational concept presented here focuses on the ability to provide ATM surface management services by leveraging new technologies to replace direct visual observation of runway operations. In lieu of the OTW view, the concept provides alternative target acquisition methods to be used for various ATM functions such as issuing clearances, alerting of runway obstructions, and providing separation assurance.

Controllers can safely make more efficient use of runways through real-time depiction of the location and intent of arriving and departing aircraft, as well as any aircraft intending to cross an active runway. For lower-demand airports, SNTs may be implemented, enabling tower services equivalent to those provided by traditional towers to be provided at more airports than is affordable today and/or for extended hours of service.

The SNT and personnel do not have to be geographically located at the airport; therefore, productivity gains may be achieved by allowing controllers to service multiple airports according to traffic ebbs and flows. This concept can, in turn, improve capacity that would typically be limited when the OTW view exceeds human effectiveness, and when precise positioning of aircraft is beyond controller visual range. The ability to use SNTs enables airports to receive tower services they would not normally, given the criteria of today and the costs of building a tower.

ATM personnel today depend on visual surveillance from the tower cab, supplemental information provided by radar, weather displays, flight strip information, and on air-ground voice communications. Controllers also receive situational awareness from various two dimensional (2-D) displays in the tower cab, and thus are familiar with, and accepting of such displays. For this reason, the SNT concept relies on the use of a large and clear integrated 2-D display that presents surveillance (surface and surrounding airspace) and weather data to the controllers. Surveillance may consist of primary surveillance (e.g., radar, inductive loops, magnetic sensors), secondary surveillance (e.g., radar and/or multilateration [MLAT]), or visual surveillance with or without image enhancement. Additionally, a suite of DSTs will provide enhanced surface management capabilities. If ADD can be obtained from the aircraft itself, that information will be integrated into the DSTs to enhance their effectiveness.

It will not be necessary for every level of SNT facility to have all of these capabilities. The integrated surveillance and weather display is, however, a necessary element for all facilities. As the volume and complexity of traffic increase, one would increasingly require the use of DSTs and ADD. Also, it is understood that all aircraft will not be equipped to send data to the ground-based ATM automation system and that the effectiveness of some of the DST functionality will depend on the proportion of equipped aircraft.

Controllers presently use 2-D displays and the altitude/speed information to create in their minds a three-dimensional (3-D) picture of the airspace and the traffic. Such a 3-D picture is critical in maintaining a full situational awareness required for managing air traffic. Researchers have long felt that controllers may be able to avoid these mental computations if the traffic data is presented to them on a 3-D display. A number of different 3-D display presentation concepts have been developed and examined by researchers around the world.

This work on these types of displays has clearly shown that if all the human factors related issues can be resolved it will be technically feasible to develop these displays for operational use. Virtual tower cabs mimicking a window view have also been developed [6]. Although the concept of virtual displays appears to be feasible, there still are several technical issues such as surveillance and display update rates that need to be resolved before these can be considered to be ready for field trials. Furthermore, even if all the technical issues are successfully resolved, it is difficult to tell if any 3-D or virtual display will find acceptance with the present controller community who have been using 2-D displays for a long time. Consequently, the SNT concept presented here is based on a conventional 2-D display. It is possible that as the technology matures and as new controllers are trained from the beginning to use new displays, 3-D and even four-dimensional (4-D) displays may, in the future, become a part of the SNT concept.

## **4.1 Alternative Display Systems for Presenting Tower Information to Controllers**

There are basically two methods of recreating an OTW view for the controllers: one is to use digital cameras for visual surveillance and the other is to use secondary surveillance to monitor the movement of aircraft on the surface and in the surrounding airspace.

Regardless of the method to recreate the OTW view, ANSP personnel will need access to various types of information in order to build and maintain their situation awareness (SA). The display used for SNT must provide comprehensive traffic information of the airport ground movement areas, surrounding airspace, and weather developments. This information includes, but is not limited to, aircraft location, aircraft movement rate, aircraft orientation, runway occupancy time, conformance monitoring, aircraft handling characteristics, runway handling characteristics, vehicle location, and non-nominal event information (e.g., runway / taxiway obstructions, unauthorized aircraft and vehicles on runway / taxiways). This list is not comprehensive and additional research will be needed to ensure that the information ANSP personnel currently acquire from the OTW view is functionally allocated to the SNT display.

### **4.1.1 Display of Visual Surveillance by Digital Cameras**

Use of digital cameras to reconstruct the window view has been examined by researchers for a number of years. The camera view may also be augmented by providing weather data and position and other aircraft data obtained via the surveillance system at the airport. Contours of the movement areas can also be superimposed on the panoramic display. Such augmentation of the camera view is clearly valuable in inclement weather when the quality of camera view is poor. It also reduces the need to switch between heads-up and heads-down position by presenting on heads-up display the data that is usually available on the heads-down displays.

### **4.1.2 Displays of Secondary Surveillance Information**

Examples of candidate display systems for presenting the secondary surveillance data to the controllers include the display used to present the ASDE-X data, the Tower Information Display System (TIDS) developed by ATO-T, the Tower Operations Digital Data System (TODDS)

developed by the William J. Hughes Technical Center, and the STARS-LITE display. Other alternative display concepts may potentially be developed. In addition, the secondary surveillance data may also be used for input into synthetic vision displays such as the one developed by Deutsche Flugsicherung (DFS).

#### **4.1.2.1 ASDE-X Display**

FAA's ASDE-X system consists of ASDE-X radar; MLAT, a secondary surveillance system; and an embedded safety logic for developing alerts for certain risk scenarios. It can also receive ADS-B data from aircraft and ground vehicles and use it as a data element in its surveillance fusion system. Its 21" color display presents accurate, reliable surveillance in all weather conditions. The display also supports additional functions including some decision support tools. The ASDE-X is presently considered only as an "advisory" system and has not been certified for providing separation service.

#### **4.1.2.2 Tower Information Display System (TIDS)**

FAA's ATO-T group has developed an early prototype version of the TIDS. In this version, the location of aircraft on the airport surface (gates, taxiways, and runways) is obtained from a form of secondary surveillance and the aircraft position in the terminal airspace around the airport is obtained from terminal radar. All aircraft and ground vehicles are shown under all weather conditions on a large (30 inch 2400x1600 pixels) 2-D display overlaid on the geographical map of the airport.

#### **4.1.2.3 TODDS Display**

TODDS integrates electronic flight data with an ASDE-X like display. It uses a variety of surveillance sources to provide a more integrated representation of the traffic situation. Design emphasis is placed on providing the ANSP personnel with a single region where position and flight data information can be acquired. Particular detail is also placed on the representation of certain types of information-instructions which can subsequently be used as memory aides for the ANSP personnel. The provision of DSTS is not a core feature of the system.

#### **4.1.2.4 STARS LITE**

STARS LITE uses STARS as its foundation and is modified for the tower environment. The system uses both primary and secondary radar to depict traffic within the immediate vicinity of the airfield. It provides conflict alerting algorithms and depictions of the weather.

### **4.1.3 Choice of Display for SNT Application**

It must be noted here that the two approaches of digital cameras and secondary surveillance are not mutually exclusive; each one may have advantages over the other for specific applications. However, one may have to choose early between ASDE-X, TIDS or another display so that one can quickly proceed with its certification for use in aircraft separation. Consequently, FAA will conduct an alternatives analysis and a comparative evaluation of the alternative display systems to determine the more viable display candidate. The focus will be on the Computer-Human Interface (CHI) and generating requirements. Also, even after a choice

is made, a significant research and development effort will be required to resolve all of the CHI issues and to define the end-state display system for SNT.

## **4.2 Decision Support Tools**

Increasing airport capacity and efficient arrival/departure management are two important elements within the SNT concept. ATM personnel will use different DST capabilities in achieving these two goals. Clearly, the list of these capabilities will evolve as the SNT technology evolves. Some candidate SNT DST capabilities are listed here but not limited to:

- Deciding the most efficient airport configuration for a given set of traffic and weather patterns
- Early planning of runway/taxiway assignments based on projected runway loading, surface congestion, user runway and gate preference and other relevant factors
- Arrival and departure management for accommodating all traffic management constraints resulting from anticipated weather conditions and resource loading
- Providing via data link information to the aircraft about airport weather conditions, runway visual range, surface conditions, braking action, current precipitation, runway availability, wake turbulence and wind shear advisories
- Providing to the aircraft via data link pre-departure clearance, taxi clearance and any revisions to clearances
- Providing via data link a coded taxi route to the aircraft
- Monitoring aircraft conformance with ATM instructions and appropriately alerting aircraft and ATM personnel
- Automatic updating of flight trajectories resulting from rerouting, ground holding, and other traffic management initiatives
- Generally creating a common situational awareness between ATM personnel, ramp personnel, airport operators, and flight operations personnel; this should greatly improve the efficiency of all surface operations including de-icing operations.

Some of the functionality of the DSTs will be more effective if it can receive ADD from the aircraft. If, however, some aircraft are not equipped to provide ADD, it will reduce the performance of the tools and such aircraft may not receive services in full. The reduction in the performance of the tools will depend on the proportion of the unequipped aircraft, and in turn will reduce the overall throughput and efficiency of airport operations. The effectiveness of these DSTs will clearly depend on the quality and accuracy of the data used by the DSTs. If DST inputs exhibit large variability, the controllers may find these tools unreliable and unusable. Consequently, the tools themselves will need extensive validation before their implementation within NextGen tower automation systems.

It must be noted here that these and other DSTs will be developed in the NextGen timeframe whether SNT facilities are implemented or not. In fact, such tools will be indispensable in developing a number of NextGen concepts in the presence or absence of conventional tower facilities at the airports.

### **4.3 Use of Aircraft Derived Data (ADD)**

It has been mentioned earlier that aircraft can provide some of the data that controllers presently obtain from visual surveillance. In the NextGen timeframe, it is expected that the aircraft can provide an extensive amount of data that will improve the overall performance of the ATM system at the NAS level. Any available media of transmission can be used for such a data transfer. A number of candidate data items for such data transfer are presented in Table 4-1. It may not be necessary to obtain all of this information directly from the aircraft; some may be obtained from flight operations center handling the aircraft operations. Furthermore, this list will evolve as the SNT technology matures over the coming years. ADD will be available from an aircraft equipped to provide ADD.

It must be noted here that presently there are no common formatting or communications standards for providing ADD to the ground ATM system and existing air-ground communications links may have to address bandwidth issues for such use. Consequently, NextGen may have to develop some commonly acceptable framework for the use of ADD by ATM systems.

**Table 4-1. Candidate Data Items for Transmission from the Aircraft**

<b>Data Items(s)</b>	<b>Use of the Data Item</b>
Aircraft ID	It will be matched to the flight plan ID from the Electronic Flight Strip (EFS)
Departure Airport, Waypoints in the Flight Management System (FMS), and Arrival Airport	DSTs will use this data for computing the aircraft trajectory. The trajectory will then be used for conformance monitoring and other ATM alerts and actions.
Aircraft Weight	DSTs will determine the aircraft type (heavy or other) and predict wake turbulence
Aircraft Capability/Service Levels	This information will support basic separation assurance, pair-wise spacing, self-separation or delegated separation.
Aircraft Performance	DSTs will compute aircraft climb-out performance
Actual Push-back time	DSTs will use it to predict wheels-off time
Aircraft in-motion indicator, surface velocity, and heading	Monitor conformance with ATM instructions, predict possible runway incursion
Taxi route and Taxi/Turning	Monitor conformance with taxi instructions
Aircraft Speed when crossing the landing runway threshold	Support Land and Hold Short (LAHSO), Ghosting, and other high throughput operations
Aircraft Braking	Predict possible runway incursions
Required distance for Take-off	Used in departure management
Actual Take-off time	Used in developing clearances for the next-in-line aircraft
Arrival time to runway threshold	Used in predicting the touch down time
Distance required for landing	Used in arrival management
Magnetic heading when stopped	Initialize automation parameters in DST
Selected Magnetic Heading	Flight path intent used in DST
Thrust setting and flap configuration	Predict aircraft performance
Emergency-related aircraft status	Initiate emergency response when necessary

## **4.4 SNT Configurations for Different Airports**

US airports exhibit a large variability in the volume and complexity of airport traffic. Consequently, one can define a number of SNT configurations appropriate for different types of presently towered airports<sup>4</sup>. For airports with low traffic and minimal complexity, SNT may have only a 2-D integrated display. For medium-sized airports, the SNT may have the display, DST functionality and the automation may use ADD when available. For large airports with high volume and complexity of traffic, SNT will have the display, DST functionality and most of the aircraft will provide ADD to the automation system. Although a choice has not been made at this time between alternative transmission media for this data exchange, NextGen is expected to develop the necessary framework in the near future. The specific configuration will be determined by cost benefit analysis on site-by-site basis by considering all the relevant factors related to the airport. For example, a low technology SNT providing the OTW view via cameras and monitors only may be considered at non-towered sites where ANT is considered now. Also, as DSTs get developed, they may be introduced in all SNT configurations as appropriate.

### **4.4.1 SNT Configuration - Display-Only**

Recent evaluations of TIDS by the FAA Airport Facilities Tower Integration Laboratory (AFTIL) have shown that an integrated 2-D display will be a very valuable element of the SNT technology. An operational version of such an integrated display will be developed after all alternatives are evaluated; a choice is made between the alternatives; and after such a system is certified for separation service.

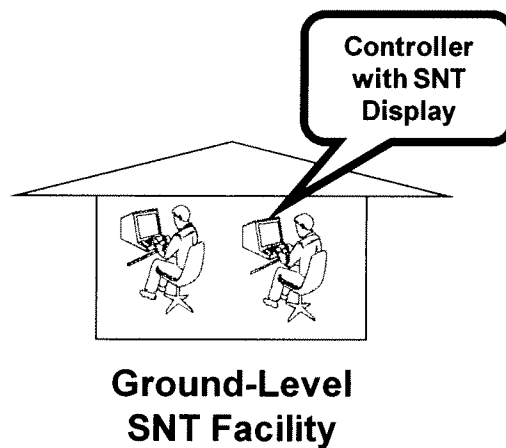
Any aircraft without a transponder onboard cannot be detected by any secondary (or cooperative) surveillance used for obtaining the location of the aircraft on the airport surface. Consequently, aircraft operating in and out of these airports must be mandated to carry a transponder. In absence of such a mandate, accommodation of unequipped aircraft would require some form of primary surveillance or some airport sensors (Millimeter Wave Sensor [MWS], Inductive Loop, Magnetic Sensor) or visual surveillance by digital cameras.

The Display-Only SNT configuration shown in Figure 4-5 can be used at some ground-level facilities for providing service to equipped aircraft operating at the airport. It is expected that Display-Only configuration will provide sufficient situational awareness for the ATM personnel for servicing equipped aircraft in and out of small airports with low volume and complexity of traffic.

This SNT configuration can also be used to provide tower-like services at presently non-towered airports. The capacity of these airports under IMC can be significantly increased with the use of SNT. DSTs may be introduced at the facilities as they become available.

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<sup>4</sup> For presently non-towered airports, ANT configuration discussed later will be more appropriate



**Figure 4-1. Display-Only Configuration**

#### **4.4.2 SNT Configuration - Display + DST**

This configuration is similar to the Display-Only configuration. However, the automation system also has DSTs with some limited-capability (such as early taxiway/runway assignment, pre-departure clearance, and coded taxi route delivery) that would improve the operational efficiency of the airport. In the next several years (2008-2012), these tools will be clearly defined, developed, and demonstrated in operational trials. It is expected that such tools would be available for implementation around the year 2012. As a result, with Display + DST configuration, SNT application can be extended to medium airports.

#### **4.4.3 SNT Configuration - Display + DST + ADD**

This SNT configuration will exhibit an integrated display, a variety of DSTs, and DST capability for the use of ADD. All aircraft are expected to carry onboard ADS-B Out equipment and a significant number will also carry datalink equipment. The airports will have some form of primary surveillance that will allow accommodation of aircraft experiencing equipment failure. The traffic density at large hub airports varies over a very wide range of the peak hourly traffic of 50-200 operations (600-3000 operations per day). Consequently, the implementation of this SNT configuration will begin at airports with relatively low density and complexity of traffic and then extend to airports exhibiting higher density and complexity of traffic.

### **4.5 Comparison of Present Tower and Staffed NextGen Tower Operations**

The present tower operations and the SNT Operations of the future are compared in Table 4-2. The present tower operations use visual surveillance out of the cab window as the basis of situational awareness. The SNT operations, however, will use surface surveillance and ADD

obtained from aircraft (if available) as the basis of this situational awareness; additionally, a suite of DSTs will significantly improve the operational efficiency at these airports.

## **4.6 Presently Unresolved Issues**

There are a number of unresolved issues that must be addressed before SNTs can be implemented across the NAS and these are described here for further analysis.

### **4.6.1 Feasibility of Replacing OTW View as Primary Information**

The SNT concept is based on replacing OTW view with alternate means of providing full situational awareness to the ANSP personnel. Surveillance and other information used by controllers today are considered as secondary information because the accuracy and integrity of such information has not yet been validated. The SNT concept proposes that this secondary information, supplemented by additional information, can be used as primary information for assuring aircraft separation. There is some experimental data obtained under operational simulation environment that supports this proposition. However, the proposed approach must be validated by extensive operational trials before the SNT concept can be considered as validated and feasible. Another related issue is how to handle emergency situations in absence of an OTW view.

### **4.6.2 Accommodation of Unequipped Aircraft**

It is expected that the majority of aircraft will be properly equipped and certified to operate at SNT airports. However, it is likely that some aircraft will be unequipped or may face equipment failures and/or other emergencies such that the aircraft is essentially operating as an unequipped aircraft. Consequently, these aircraft must be accommodated within the SNT concept of operations.

This issue may possibly be resolved in the future if some form of primary surveillance and/or advanced virtual displays are shown to provide the controllers with sufficient situational awareness. In absence of primary radar or airport sensor surveillance, however, it appears that some form of visual surveillance by cameras will be necessary at the airport to accommodate any unequipped aircraft.

### **4.6.3 Human-Machine Interface and Human Factors**

Servicing traffic in and out of an airport without the window view from the tower cab is understandably a major paradigm shift in air traffic management. This paradigm shift can have major human factors implications such as:

- human performance (e.g., human capabilities and limitations, human error, situational awareness, workload, function allocation, hardware and software design, procedural design, decision aids, special tools, user manuals and documentation, warnings and alarms, environmental constraints, workspace, and team versus individual performance),
- staffing (e.g., staffing levels, team composition, job design, team communication, and organizational structure),

- personnel selection (e.g., minimum skill levels, special skills, experience levels, and cultural issues), and
- training (e.g., training regimen, training effectiveness, skill retention and decay, retraining, emergency operations training, training devices and facilities).

The concept and potential solutions must be examined extensively in laboratory and operational environments before deciding the configuration for SNT implementation, and the full set of human factors issues must be identified and resolved as the SNT concept matures.

**Table 4-2. Comparison of Present OTW Tower Operation and SNT Operation**

Tower Functionality	Who does it	Present Operation with OTW View		Future SNT Operation without OTW View		Unresolved Issues
		Systems and Equipment in Use	Contribution of the OTW view	Possible Mitigation in absence of OTW	Future Systems and Equipment	
Weather Sensing at the Airport	Flight Data Control position monitors the weather changes between automatic updates.	AWOS, ASOS, Low-Level Windshear Alert System (L LWSAS), Next Generation Weather Radar (NEXRAD), Terminal Doppler Weather Radar (TDWR), and others installed by the airport operator collect weather data. Weather is also available from Flight Data Input/Output (FDIO) messages and other sources such as National Weather Service and NOAA	Controllers visually monitor changing weather between automatic updates	Period of automatic weather updates must be reduced as necessary. Visual scanning by digital cameras is also an option.	Present sensors will continue to be used; however, all sensors including reports from aircraft will interface with each other according to the NNEW concept. Also, weather products will follow 4-D weather-cube (x, y, z, and t) format. A specific portion of this weather cube will be identified as 4-D Weather SAS for use in ATM automation system.  The weather and the traffic data will be presented to the controller on a single display. Such a single display will avoid the discontinuities associated with a mixture of heads-up and heads-down operations.	The minimum required weather update rate is undefined.
Distribution of Weather and other data such as Notices to Airman (NOTAMs) and Bird Activity	Flight Data Position composes the ATIS or D-ATIS messages	Automated Terminal Information System (ATIS), Digital ATIS, and by Radio Communication with aircraft	None	N/A	The weather distribution will be implemented in a net-centric way according to NNEW concept. Furthermore, weather information will be accompanied by an assessment of its impact on the user flight(s). In addition, ATIS or Digital ATIS (D-ATIS) type service will continue to be provided. Weather products may be distributed to the pilot via digital voice or data link as appropriate.	

Tower Functionality	Who does it	Present Operation with OTW View		Future SNT Operation without OTW View		Unresolved Issues
		Systems and Equipment in Use	Contribution of the OTW view	Possible Mitigation in absence of OTW	Future Systems and Equipment	
Initial Clearance Delivery	Clearance Delivery Position Pre- Departure Clearance (PDC) delivery may be automatic	PDC via Aircraft Communications Addressing and Reporting System (ACARS) and/or via voice communication to the aircraft	None	N/A	All clearances and related revisions will be sent to the aircraft via voice or Data Communications	

Tower Functionality	Who does it	Present Operation with OTW View		Future SNT Operation without OTW View		Unresolved Issues
		Systems and Equipment in Use	Contribution of the OTW view	Possible Mitigation in absence of OTW	Future Systems and Equipment	
Pushback into Movement area	Ground Controller	Limited situational awareness possible with ASDE-3 or ASDE-X radar and/or MLAT if there is coverage of the Gate area.	Situational awareness is mainly by visual surveillance via OTW view	Gate area must be covered by sufficient secondary surveillance and aircraft must be equipped with a transponder. Primary surveillance must be provided to monitor ground vehicles.	Position of aircraft and ground vehicles on airport surface presented directly on the SNT Display. Conformance monitoring may also be available. Clearances will be transmitted by voice or by data communications as appropriate.	Presently the surface surveillance is considered as secondary information and ASDE-X, AMASS and similar systems are considered only as "advisory". These systems must be certified for separation service.  Ability to identify and remove false targets in gate area requires additional research.  Safety and human factors issues associated with the loss of the 360 degree OTW view would need to be resolved.

Tower Functionality	Who does it	Present Operation with OTW View		Future SNT Operation without OTW View		Unresolved Issues
		Systems and Equipment in Use	Contribution of the OTW view	Possible Mitigation in absence of OTW	Future Systems and Equipment	
Taxi Clearance	Ground Controller	Limited situational awareness possible with ASDE-3 or ASDE-X radar and/or MLAT if available	Situational awareness is mainly by visual surveillance via OTW view	Secondary surface surveillance must be provided and aircraft must carry a transponder. Primary surveillance must be provided to monitor ground vehicles.	Position of aircraft and ground vehicles on airport surface presented directly on the SNT Display. Automated conformance monitoring DST will be provided to assist the controller and provide safety alerts if a runway incursion situation develops. Also, DSTs will generate taxi plans for efficient aircraft movement on the surface. Clearances will be transmitted by voice or by data communications as appropriate.	As above under Pushback into Movement Area Ability to identify and remove false targets in gate area requires additional research.

Tower Functionality	Who does it	Present Operation with OTW View		Future SNT Operation without OTW View		Unresolved Issues
		Systems and Equipment in Use	Contribution of the OTW view	Possible Mitigation in absence of OTW	Future Systems and Equipment	
Take-off Clearance	Local Controller	A clearance based on radar/non-radar and visual separation standards is issued by the Local Control and is transmitted to the aircraft via voice communication	Situational awareness is based on visual surveillance through the cab window	Secondary surface surveillance must be provided and aircraft must carry a transponder. Primary surveillance must be provided to monitor ground vehicles.	Same as above.	Safety and human factors issues associated with the loss of the 360 degree OTW view would need to be resolved. Ability to identify and remove false targets in gate area requires additional research.
Runway Obstruction Alert	Local Controller	Runway incursion alerting system such as Airport Movement Area Safety System (AMASS) or ASDE-X is presently available at some airports. An alert is transmitted via voice communications	Runway obstruction is detected via visual surveillance. Automated alerts only cover a limited number of incursion scenarios	Primary surveillance and/or special airport sensors will detect runway obstructions at large airports.	Automatic alerts will be issued to controllers and pilots when obstructions are detected at large airports. At small airports without primary surveillance or airport sensors, such alerts will not be provided.	Same as above. Acceptance of reduction in service at small airports. Some form of such alert may be provided by an airport based system.

Tower Functionality	Who does it	Present Operation with OTW View			Future SNT Operation without OTW View		Unresolved Issues
		Systems and Equipment in Use	Contribution of the OTW view	Possible Mitigation in absence of OTW	Future Systems and Equipment		
Separation Assurance	Ground and Local Controllers	Some tools such as Conflict Alert (CA), Minimum Safe Altitude Warning (MSAW) are available for use by controllers. AMASS or ASDE-X is available at some airports. Appropriate alerts based on the above systems or on visual surveillance are issued to pilots via voice transmission	Ground and Local controllers use visual surveillance to obtain situational awareness. Automated alerts by AMASS and ASDE-X only cover a limited number of incursion scenarios	Ground and terminal surveillance data from sensors located at the airport will be displayed on the SNT Display. Conformance monitoring tools will be available to controllers.	Alerts will be issued via voice or data transmission. Pilots will continue to be responsible for visual acquisition of aircraft. Responsibility for some pair-wise separation scenarios may be transferred to aircraft that are equipped with "sense and avoid" capability.	Safety and human factors issues associated with the loss of the 360 degree OTW view would need to be resolved.	
Traffic Flow Synchronization	Traffic Management Coordinator or Tower Supervisor	Based on flight plan, radar data, and applicable TMs, controllers identify an appropriate traffic sequence, spacing, and routes/reroutes to achieve proper synchronization	Surface congestion and gridlock conditions will be noticeable via OTW view	Surface congestion and gridlock conditions will be noticeable on the SNT display.	TMI and flight plan data will be available to users and controllers via net-centric information system and will significantly improve common situational awareness. DSTs will assist the controller with planning taxi routes and arrival and departure sequencing. Responsibility for some traffic synchronization scenarios may be transferred to aircraft that are equipped with "sense and avoid" capability.		

Tower Functionality	Who does it	Present Operation with OTW View		Future SNT Operation without OTW View		Unresolved Issues
		Systems and Equipment in Use	Contribution of the OTW view	Possible Mitigation in absence of OTW	Future Systems and Equipment	
Scanning for Emergencies on Airport Surface	Ground and Local Controllers	None	Visual scanning of the airport surface	Visual scanning by digital cameras. Use of ADD related to aircraft emergencies Transfer of certain responsibility to airport authority may also be an option.		Due to fidelity and update rate issues, digital cameras may be suitable only for small airports  Aircraft may not be equipped to provide ADD and/or may lack sensors to detect events such as blown tires and wheel assembly fires.  Safety and human factors issues associated with the loss of the 360 degree OTW view would need to be resolved.

#### **4.6.4 Workforce Transformation**

The FAA personnel management in the NextGen timeframe is expected to be significantly different than that of today. Staffing of ATM facilities will be much more flexible and will be significantly unconstrained by facility boundaries. Co-location of operational domains of differing complexity into general service delivery points will result in reduction of infrastructure and Operations and Maintenance costs; such co-location will also provide valuable flexibility in staffing.

The SNT implementation, in particular, may cause certain mismatches between the need and the availability of staffing across geographical areas of the NAS. If one SNT facility services more than one airport, the facility and the personnel may cross existing regional organizational boundaries.

As the SNT technology matures, one must examine in detail all the workforce related issues and resolve these issues as necessary.

## 5 An Operational Concept for an Automated NextGen Tower (ANT)

Presently there are several thousand small airports that have no control tower at the airport. The capacity, traffic demand and complexity of traffic at these airports are minimal. IFR approach services to the pilot are currently provided by the ATC personnel either at a Terminal Radar Approach Transceiver (TRACON) or Air Route Traffic Control Center (ARTCC) designated to provide these services. The Visual Flight Rules (VFR) operations in the airspace surrounding the airport and all operations on the airport surface are generally uncontrolled. Pilots assume the separation responsibility for IFR operations until the aircraft is in *controlled* airspace with published operational procedures; controllers then take over the separation responsibility from the pilots.

Flight planning related to operations at non-towered airports is done by the pilot or the flight operator. Route and weather briefings are available from the Flight Service Stations (FSS). Additional or supplemental weather information is available also from National Oceanic and Atmospheric Administration (NOAA), and systems such as Digital User Access Terminal (DUAT) that can assist the pilot in flight planning. Under VFR operations, pilots maintain a situational awareness by listening to the communications on published common traffic advisory frequency or the airport UNICOM and are responsible for their own separation. Under IFR operations, pilots may get departure clearances over the phone from the TRACON or the ARTCC responsible for the airport. The clearances may be relayed through FSS from the ATC facility. Generally these clearances have a *void time* and the flight must take off before this void time; if not, a new clearance must be obtained. Generally IFR operations follow the conventional *one-in, one-out* rule, and all other IFR aircraft requesting approach or departure will be on hold during this time. ATM does not provide any separation services on the airport surface; the aircraft departing in IMC receives separation services only after the aircraft enters *controlled airspace*.

The IFR capacity during IMC conditions at these airports is severely restricted with the one-in, one-out rule. Clearly there will be no benefits to the users if the ANT facility simply duplicates the present operations and only eliminates the human role in supporting these operations. The concept presented here attempts to improve on the services provided at the airports, specifically for operations under IMC. The weather information and flight planning assistance will continue to be provided as now from Automated Flight Service Station (AFSS), NOAA and commercial vendors. However, all weather information will be integrated according to the NextGen Net-Enabled Weather (NNEW) concept. A portion of the 4-D weather cube will be identified as 4-D Weather Single Authoritative Source (SAS) for use in the ATM automation system. The ANT will provide Sequencing services to the traffic in and out of the airport being serviced. It may provide separation services on the airport surface and/or in the airspace surrounding the airport; clearly this will depend on the aircraft equipage and surveillance infrastructure at the airport. If the aircraft is equipped with some data link capability, Traffic Information Service-Broadcast mode (TIS-B) capability, or with some other type of *sense and avoid* capability, the separation responsibility may be fully allocated to the pilot under certain pair-wise separation scenarios. These scenarios include, for example, in-trail following behind

another aircraft equipped with ADS-B Out or merging behind an aircraft equipped with ADS-B IN/OUT.

Presently there are several hundred non-towered airports that have traffic, although minimal (peak of < 5 operations per hour), that is comparable to traffic at many towered airports. On a case-by-case basis, some of these airports may be candidates for ANT implementation. Furthermore, there are a number of presently towered airports that operate for a limited number of hours every day. Potentially their operating hours can be extended or they may be serviced during their off-peak hours with the use of ANT facilities. In absence of ANT, such operations would have to be like non-towered operations. Consequently, ANT operations are compared here with non-towered operations.

## **5.1 Description of ANT Operations**

The present non-towered operations and the ANT Operations of the future are compared in Table 5-1. The IFR capacity at these airports is expected to be significantly increased with ANT without the need for an expensive airport tower.

## **5.2 Need for Surveillance Infrastructure**

The ANT system cannot provide arrival sequencing and separation service in the airspace unless it knows the position of all aircraft in the airspace surrounding the airport. Consequently, it is assumed that all aircraft operating in and out of the airport will be under surveillance at all times. Presently the FAA has issued a Notice of Proposed Rulemaking (NPRM) related to mandating ADS-B Out for aircraft operating in certain types of airspace in the year 2017 and beyond. However, this proposed mandate does not cover Class D airspace and Class E airspace less than 10000 feet above Mean Sea Level (MSL). Consequently, one can expect that for the foreseeable future FAA may have to accommodate a significant number of unequipped aircraft at the ANT airports. As a result, FAA must either provide primary surveillance of the related airspace, or extend the mandate for ADS-B equipage to this airspace, or provide ADS-B avionics to the unequipped aircraft. Similarly, if ANT is to provide separation service on the airport surface, it must provide such surveillance on the airport surface.

Primary surface surveillance radars (Airport Surface Detection Equipment, ASDE-3 or ASDE-X) have been in use in the NAS for almost two decades. However, small airports will not have any surface movement radar and surrounding airspace for most may not have coverage even from any distant radar. Clearly investment for new surface radar cannot be justified at these airports; however, there are a number of alternatives for providing primary surveillance on the surface and in airspace surrounding such airports. Examples include the use of a multilateration system (MLAT), inductive loops or magnetic sensors on runways and taxiways. A cost benefit analysis would need to be conducted to determine the most cost effective system to use.

It must be noted here that any implementation of the surveillance infrastructure at a potential ANT-serviced airport will have to be justified on an investment analysis conducted on a site-by-site basis. Also, mandating or paying for equipping presently unequipped GA aircraft will have to go through a cost-benefit analysis.

### **5.3 Need for a Communications Frequency for ANT Facility**

The ANT separation service will include issuing alerts to the pilot of potential violation of separation standards. Such an alert will be issued with the help of digital voice transmission. The existing common-use UNICOM system cannot guarantee timely receipt of the alert by the pilot and cannot be used for this purpose. Consequently, one must allocate a communications frequency for use by the ANT facility. Such allocation of separate frequencies for ANT facilities will result in worsening the spectrum congestion problems. These alerts may also be transmitted via data link to the equipped aircraft if such transmission is shown to provide assured delivery.

### **5.4 Presently Unresolved Issues**

There are a number of unresolved issues that must be addressed before ANTs can be implemented across the NAS. Among others, these include:

- Safety of normal operations and handling of emergencies
- Human factors and human interface issues related to pilots and aircraft operating from ANT airports
- Accommodation of unequipped aircraft and of aircraft with onboard emergencies
- Spectrum congestion caused by the need for a separate communications frequency for an ANT
- Accuracy of speech recognition and speech synthesis
- Training and certification of pilots for operating in and out of ANT airport
- Concept for providing a backup to the ANT facility in case of failure
- Certification of ANT facility, airport and aircraft systems necessary for supporting ANT operations

Some of these issues have been discussed earlier as they relate to an SNT facility and clearly need further analysis.

**Table 5-1. Comparison of Present Non-Towered and ANT Operations**

Weather Sensing at the Airport	Different systems such as Automated Weather Observing System (AWOS), Automated Surface Observing System (ASOS), and others installed by the airport operator collect weather data	Present sensors will continue to be used; however, all sensors including reports from aircraft will interface with each other according to the NNEW concept. Also, weather products will follow 4-D weather-cube (x, y, z, and t) format. A specific portion of this weather cube will be identified as 4-D Weather SAS for use in ATM automation system.
Weather Distribution	By Voice Communication with the aircraft or by an automated weather station installed at the airport	The weather distribution will be implemented in a net-centric way according to NNEW concept. Furthermore, weather information will be accompanied by an assessment of its impact on the user flight(s). In addition, Automated Terminal Information System (ATIS) or Digital ATIS (D-ATIS) type service may be provided (will need concept development). Advanced weather products, if and when available, will be distributed to the pilot via digital voice or data link as appropriate.
Taxi and Take-Off Clearances	Clearance with an <i>if not off by</i> void time is usually delivered by voice from AFSS, or TRACON or ARTCC	Voice recognition technology will be used for processing pilot requests and for evaluating the read-backs; digital voice systems will be used for delivery of clearances. Data link transmission may be used for equipped aircraft.
Runway Obstruction Alert	Not provided	ANT automation will not provide such an alert. Some form of such alert may be provided by an airport-based system.
Separation Assurance in non controlled airspace and airport runways and taxiways	The pilot is responsible	It is assumed that the airport has secondary surveillance on the surface and in surrounding airspace. For unequipped aircraft, pilot will continue to be responsible. ANT may provide alerts to equipped aircraft if the automation system has some conflict prediction capability.
Traffic Flow Synchronization	Traffic synchronization is inherently achieved because the clearances received from ARTCC or TRACON are consistent with applicable TMIs	Traffic Management Initiatives (TMIs) and related data may be entered into the ANT automation system either by ARTCC or TRACON personnel as appropriate. Runway configuration changes and arrival/departure rates may be entered into the ANT automation system by ATM or possibly by airport personnel. ANT automation system will provide synchronization capability and issue appropriate clearances. For commercial aircraft operations, collaborative decision making may be introduced if and when possible.

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## **Appendix A     A Notional Flight Scenario at a Large SNT Airport in IMC**

This appendix describes the SNT concept in terms of a notional<sup>5</sup> operational scenario for a flight departing from and arriving at a high density hub airport under low visibility instrument meteorological conditions (IMC). The departure and arrival airports have multiple taxiways and parallel/crossing runway configurations. The scenario begins with the planning for operation of a typical flight (ABC 123) of the future and ends when service provider closes the flight at the arrival airport. This description may be used to identify the needs and requirements of the National Airspace System (NAS) Users and service providers. It must be noted here that in the NextGen environment, the pilots and the Flight Operations Center (FOC) personnel will be unable to distinguish at operational level between services received from an SNT facility and from a conventional airport tower. The only difference between these operations will be at a functional level for ATM personnel. At a conventional airport tower, both visual and radar surveillance will contribute to the controller situational awareness whereas at an SNT such awareness will be based on the integrated display of surveillance and weather data and on the aircraft-derived data received from the aircraft via data link. As a result, these scenario descriptions also basically reflect on the NextGen environment that is common to conventional tower and SNT facilities.

### **A.1 Gate to Take Off**

In the flight planning phase, the FOC has submitted the user preferred profile and it is being coordinated with the system flight planning function. This function provides the user with a feedback on weather along the preferred trajectory and its impact on the flight, any current constraints in the airspace or at the airport, and expected traffic volumes and potential for delay. A flight profile is then negotiated that accommodates the user preference for the flight and is consistent with the applicable constraints. The user also indicates an alternative profile that would utilize previously constrained airspace (e.g., Special Use Airspace [SUA], and convective weather), should it become available.

There are no inherent differences in the manner in which an individual flight for a single user or a fleet is coordinated with the air traffic system. The FOC can, however, attempt to meet a company objective by making trade-offs at the fleet level among the profile allocations of individual flights.

This is not the system's first knowledge of the flight. Previously, the airspace user had notified the ATM system of the potential for the flight, allowing for strategic planning based on the expected flow, the historically dominant weather/winds patterns, and any other constraints. This strategic allocation was entered into the service provider's master airspace database. Also,

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<sup>5</sup> As discussed in earlier in the document, there are a number of important issues that must be addressed before any NextGen Tower concept can be implemented. The actual fielded SNT system and the flight scenario may be quite different than the one described in this Appendix. Consequently, this scenario should be considered as notional.

it is made available, graphically and in text format, to ATM personnel and to any flight planning function supporting a user with a desire to access the airspace.

On the actual day of operations, a lesser degree of system flexibility is available than in earlier planning stages. The system will factor in weather as a possible constraint, and will evaluate the allocation of airspace and traffic. The departure planning and surface management functions of the DST will now consider these limitations and adjustments to service provider allocations. The flight crew will now access System-Wide Information Management (SWIM) network, either in the terminal area or in the cockpit, and received its flight information briefing. The briefing function provides access to the FOC, to the Air Traffic Control System Command Center (ATCSCC) traffic management function and to pertinent aeronautical information.

The flight crew will receive via SWIM all information contained in a common airspace registry along both the adapted and alternative route profiles. The data in the common airspace registry can be sent either automatically or upon request to the aircraft's onboard Flight Data Manager (FDM) or to the Electronic Flight Bag (EFB). By registering flight profiles or volumes of interest, the system will automatically send any changes that affect either the profile or the volume. Similarly, the user can identify a volume of airspace or a resource asset and receive all related information. The pilot also obtains all departure airport data pertinent to the flight such as, for example, the weather conditions, the active runway, and Notices to Airmen (NOTAMs).

The flight crew familiarizes themselves with the details of the flight's coordinated profile. The flight-coordinated profile will include the actual and forecast weather conditions, the airspace structures in operation on their route, etc. At this time, the flight crew will confirm or update their intended push-back and departure times. Upon receipt of the confirmed departure time from the user, the system will perform tactical and strategic flow analysis to determine if the aircraft needs to incur a ground delay. The surface management Decision Support System (DSS) will produce optimal times to taxi and takeoff to the flight crew and to the SWIM which updates the profiles in the common airspace registry.

The surface management function of the DST will seamlessly interface with all other NAS automation elements through SWIM and will identify the optimal time to implement planned changes to runway configuration based on projected ground and airborne traffic flows. The airport taxi plan will incorporate the planned runway configuration change and determine the appropriate aircraft to be directed to runways in use. As a result, the system continues to operate at maximum efficiency with minimal delay to both ground and airborne traffic.

The generation of individual flight profiles, based on the long-term planning with adjustments for the day's events, is used to load the airport's surface management DST. Based on the profiles and expected times of departure, the surface management DST develops an initial allocation of flights to departure runways. For some flights, the delay in departure while waiting in queue will exceed the increase in airtime if departing on another runway. The surface management DSS will offer the alternatives to the FOC planning system, and when negotiated and accepted, the new runway assignments and departure profiles will be available for the en route systems to adjust the strategic plan.

The flight crew in the cockpit has now powered up the systems; a signal will be delivered to the NAS System alerting all facilities involved that this flight is preparing for departure and intends to enter the NAS at the previously coordinated or an updated time.

The crew is completing its preflight checklist. They ensure the aircraft (FDM or EFB) reflects the current agreed upon profile, which was uploaded into ABC 123's Flight Management System (FMS) via data link from the FOC. The flight information provided by the FOC would include items such as the route of flight, convective weather, SUAs, slot times, airport or en route delays, etc.

The ATM clearance information will be provided by the service provider to the aircraft via direct data link in the cockpit, and the pilot will use automation to acknowledge its receipt. The aircraft sends a signal directly to ramp control, if required, and/or to Service Provider when the aircraft is prepared to taxi from the gate area to the active taxiway.

The aircraft receives a coded taxi clearance and starts to taxi to meet its assigned departure time. The aircraft is provided via data link up-to-the-minute information (e.g., clearances, airport information, NOTAMs, weather conditions, etc.). The entire airport movement area is already registered into a geographical information database system. Cockpit staff can access this database to view any information of interest in textual and graphical format on a multi-functional flight deck display. Information may include the following: ATM clearances and messages, traffic information, moving maps, terrain displays, weather, aircraft and flight monitoring, portions of the movement area that are not available for use, and other applicable information.

Automated systems will monitor the aircraft position on the airport movement area and present it on the SNT Display. The aircraft cockpit display will show the fixed obstacles and traffic (aircraft and vehicles) in reference to the visual references on the airport movement area. The automation system will assist ABC 123 with appropriate airport signage and lighting to be in compliance with the taxi plan. Both aircraft and tower automation will monitor aircraft conformance with its assigned taxi route and will provide appropriate alerts to the controller and the pilot of discrepancies, and thus will help avoid deviations possibly leading to runway incursions. Such monitoring will allow the service provider to both identify and resolve as early as possible any potential problem, or to indicate to the system that the deviation from the taxi plan is an acceptable modification. The surface management DSS will be sufficiently dynamic to allow the service provider to amend the taxi plan or sequences for any flight. Based on the service provider inputs, the system will update all affected taxi plans and present them to service provider for execution. The new taxi plan is delivered via data link to the ABC 123 flight deck. The surface management DSS will use position reporting and any modifications to the taxi plan to provide updates on expected queue order to the service provider.

With the poor visibility in IMC, visual navigation on the airport surface is not possible. However, the flight crew will be assisted by the flight deck display that allows them to "see" by giving them precise graphical representations of their surroundings in relation to the aircraft position. Delays due to reduced visibility will be minimized for equipped aircraft and a comparable level of throughput will be achieved as in good visibility conditions.

Ground vehicles may also be equipped for cooperative surface surveillance and vehicle management. Some vehicles will require transmittal of position only, while others, such as operations and fire fighting vehicles, will have the ability to display positions of aircraft and other vehicles to the operator.

The aircraft has now reached the runway and is next for departure at the system assigned time. The service provider clears the aircraft for takeoff without any additional delay and the aircraft takes off. As the flight enters the en route airspace, its control is transferred to the controllers at the en route General Service Delivery Point (GSDP), presently called the ARTCC. The flight then traverses the en route airspace, is controlled by the appropriate GSDP personnel, and arrives in the vicinity of the arrival airport.

## **A.2 Final Approach to Gate**

Throughout the flight, the crew has received via SWIM all updated arrival airport information such as the weather conditions, the active runway, and NOTAMs etc. As the aircraft approaches its destination airport the flight crew's flight management system continues to implement these updates to the arrival trajectory. The national and local traffic flow system has had access to all trajectory updates for ABC 123. The tactical flow management tools have received the gate assignment registered in the flight object for this flight. The gate assignments for all aircraft arrivals within the same time window are evaluated and an appropriate runway is assigned to ABC 123. This runway assignment is used to update the adapted profile down to the threshold. ABC airlines ramp control has access to the adapted profile via the Common Airspace Registry. The profile provides ABC ramp control with the latest data on arriving traffic and provides the ramp controller with ABC 123's estimated touchdown time.

Since an arrival time for the flight has been established, the surface management decision support tool (DST) uses the trajectory coordinated between the user and the service provider and develops the optimum taxi plan for the aircraft to its gate. All airport conditions, vehicle and aircraft traffic are incorporated into the taxi plan. The service provider reviews/approves the taxi plan and it is transmitted via data link to the aircraft and to the ramp control. The taxi and gate times contained in the taxi plan are then sent back to SWIM. The flight crew can view their assigned taxi route on their flight deck display.

ABC 123 has now landed and is rolling out on the runway. As the aircraft exits the runway it has received clearance from the service provider to execute the taxi plan to the gate/ramp already assigned to it by the ATM system. The automated system provides specific airport signage and lighting to assist ABC 123 execute ground movement in compliance with the taxi plan.

All airport information is maintained in a geographical information database. ABC 123 accesses this database and views the fixed obstacles and traffic (aircraft and vehicles) in the airport movement area on the flight deck display, and when able, correlates them with outside visual references. The display provides in textual and graphical format the identity, position and short-term intentions of other maneuvering aircraft and vehicles. Other information on the display may include ATC clearances and messages, traffic information, moving maps, terrain displays, weather, aircraft and flight monitoring, portions of the movement area that are not available for use, and other pertinent information. Both the aircraft and the tower automation

will monitor aircraft conformance with the system assigned taxi plan and will provide alerts to the controller and pilot of any discrepancies, thus avoiding deviations that may cause runway incursions. The automation system will monitor the time-to-gate and speed along the taxi route; these measurements help one to identify potential areas of congestion. They are also used in estimating the taxi-in (and taxi-out during departures) times as well as in the development of taxi plans. Such monitoring also allows the service provider to both identify and resolve a potential problem as early as possible.

The poor visibility in IMC makes it impossible to navigate on the airport surface by visual surveillance. However, the flight deck display of relevant information described above results in a throughput comparable to that achieved as in good visibility conditions. As a result, delays are minimal even in the reduced visibility in IMC.

Ground vehicles will also be equipped for surface surveillance and surface movement management. Some ground vehicles will be required to send only their position data, while others, such as emergency and fire fighting vehicles, will have the ability to display positions of aircraft and other vehicles to the operator.

Upon engine shutdown all information about the flight is archived including any restriction, strategic/tactical flow profiles that were developed. This data will then be used in post-day analysis and as the basis for historical preferred profiles for later use in the long-term planning functions.

## **Appendix B      Transition towards Staffed NextGen Towers**

The NextGen Concept envisions implementation of SNT facilities beginning around the year 2017. There are a number of on-going research and development efforts in Europe and in the United States that are addressing various components of this technology. The FAA, for example, recently developed and evaluated one version of an integrated tower display (TIDS) using surface surveillance data. FAA will also conduct comparative evaluation of alternative display systems in simulated environment. When a specific alternative is selected, it will be operationally evaluated with a real airport environment.

The definition of the specific DST functionality requirements and their subsequent development and implementation is expected to be done within the next several years. Also, it will take a number of years before various items of airport-related data transmitted from the aircraft will be incorporated into SNT system development. There are, however, different elements of the SNT technology that can be incrementally introduced within the NAS operations when they become available.

The different SNT configurations described earlier can be implemented at appropriate airports depending on their traffic levels. The high-end airports already have primary and secondary surveillance of airport surface and surrounding airspace and the aircraft operating from these airports carry advanced avionics. Consequently, one can presumably begin SNT implementation at these high-end airports as soon as the safety, certification and other issues are resolved. On the other hand, the density and complexity of traffic is minimal at small airports and SNT implementation will presumably be easier and less risky. However, the necessary surveillance infrastructure is lacking at these airports. Consequently any SNT implementation will require an initial investment for providing the necessary secondary surveillance. Heuristically it may appear that one should begin SNT implementation at small airports and then expand implementation to medium and large airports. However, there are other factors at play that are equally important.

The SNT technology will provide a number of benefits for the FAA. In the short-term, although SNT facilities cannot be implemented at the large airports, just the introduction of SNT displays and DSTs in the present tower cabs at these airports will enhance the efficiency and safety of their operations, and increase their throughput in poor visibility and night conditions. Also, this technology will allow airports to add runways on their property even with some unresolved line-of-sight issues because controllers will be able to control traffic without direct visual observation of the added runway. In the short term, implementation of SNT facilities at small and medium airports may lead to saving in facility construction costs. Clearly such cost saving is possible only if the FAA decommissions old tower facilities and does not replace them with new towers. However, such a major paradigm shift may not be possible in the short term. Consequently, it is suggested here that FAA continue to develop NextGen technologies but presently implement them only in tower cabs at the large airports to obtain immediate capacity benefits. The proposed schedule of activities presented later in Figure C-4 is therefore based on this approach. Once all the SNT technologies are developed, SNT facilities can be implemented in the future when the present airport towers are decommissioned without being replaced.

All SNT configurations should be implemented through three specific transitional configurations as follows.

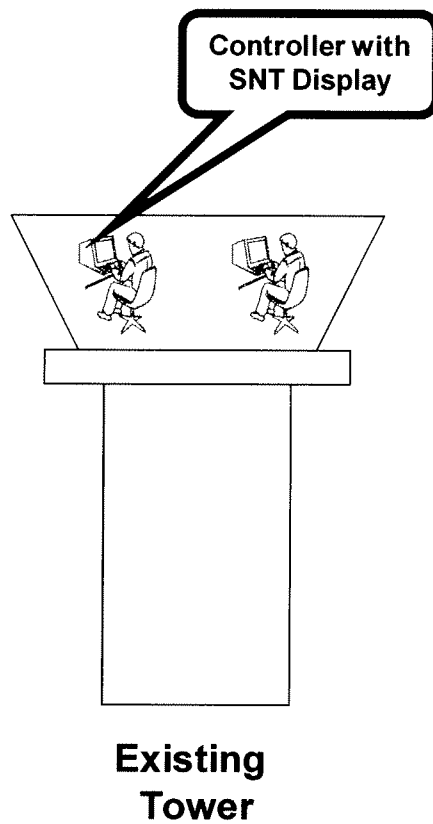
### **B.1 Supplemental Configuration**

As a first transitional step, SNT Display should be introduced in the existing tower as in Figure C-1. Qualitatively SNT Display is expected to be far more superior to any displays presently in use. Consequently the Ground and Local controllers will have vastly improved situational awareness of the traffic on runways and taxiways; the controllers will continue to have the window view as usual. Use of SNT Display could, therefore, increase the airport capacity under low visibility and night conditions, in turn, resulting in reduction of airport delays.

Implementation of such Supplemental Configuration will provide the controllers with valuable experience with SNT Display and will go a long way towards the transition to the full SNT implementation.

The operations at the large airports can be significantly improved in the near term by simply introducing the SNT Displays that can visually augment the situational awareness of the controllers, especially under IMC.

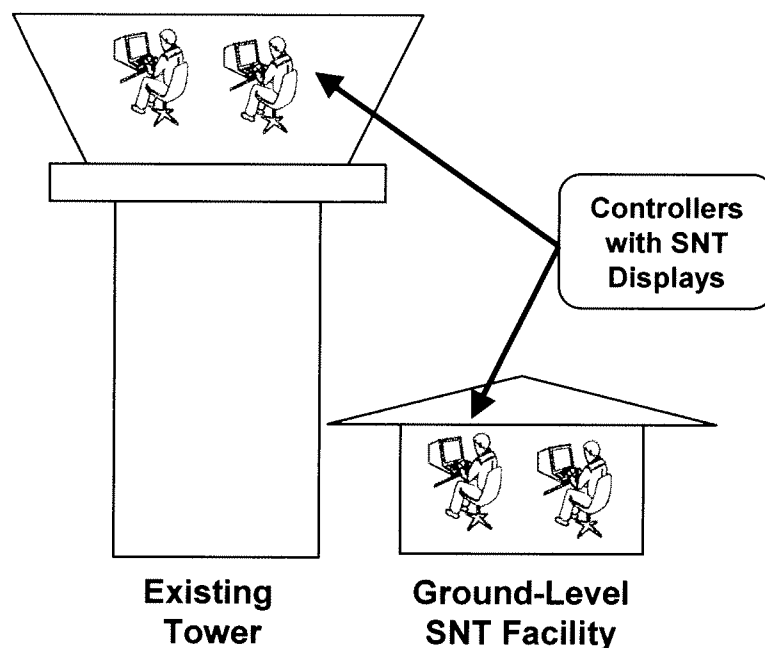
There is another potential application of such Supplemental configuration that may provide early benefits for some large airports. It is possible that some large airports may be planning to add a runway that may not be visible from the cab on the existing tower. The conventional approach is to build an additional tower at a suitable location so that controllers will be able to view the new runway. In such a situation, however, one can install SNT at a controller position in the existing tower and that controller position can then be used to service operations on the added runway. The conventional Local and Ground positions will then continue to service operations on the runways visible from the existing tower. Also, occasional unequipped aircraft can operate from these older runways.



**Figure B-1. Supplemental Configuration**

## **B.2 Flexible Configuration**

After some initial experience with Supplemental Configuration, one would take the next transitional step of the Flexible Configuration shown in Figure C-2. In this configuration, a ground-level SNT facility would be developed so that the airport can be serviced either from this facility or from the existing tower. The SNT Display and available decision support tools will be used in the remote ground-level facility as well as in the existing tower cab. Such Flexible configuration will give controllers experience with these operations and give workforce planners flexibility in training and scheduling the remote facility workforce.

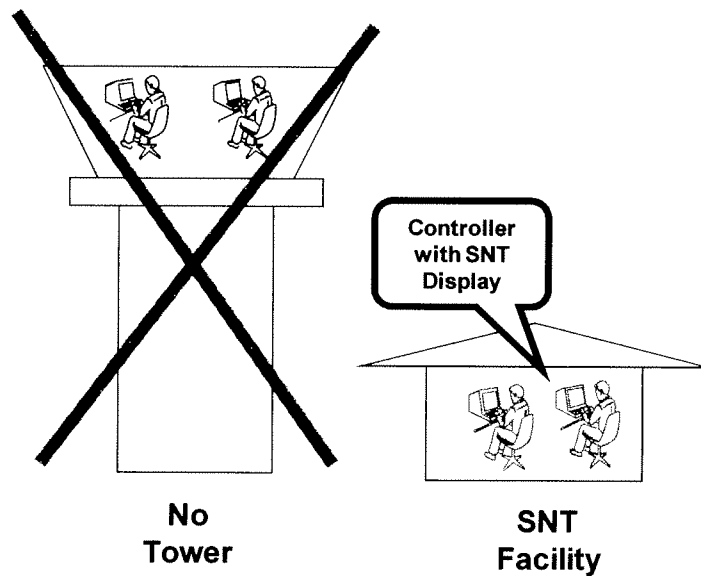


**Figure B-2. Flexible Configuration**

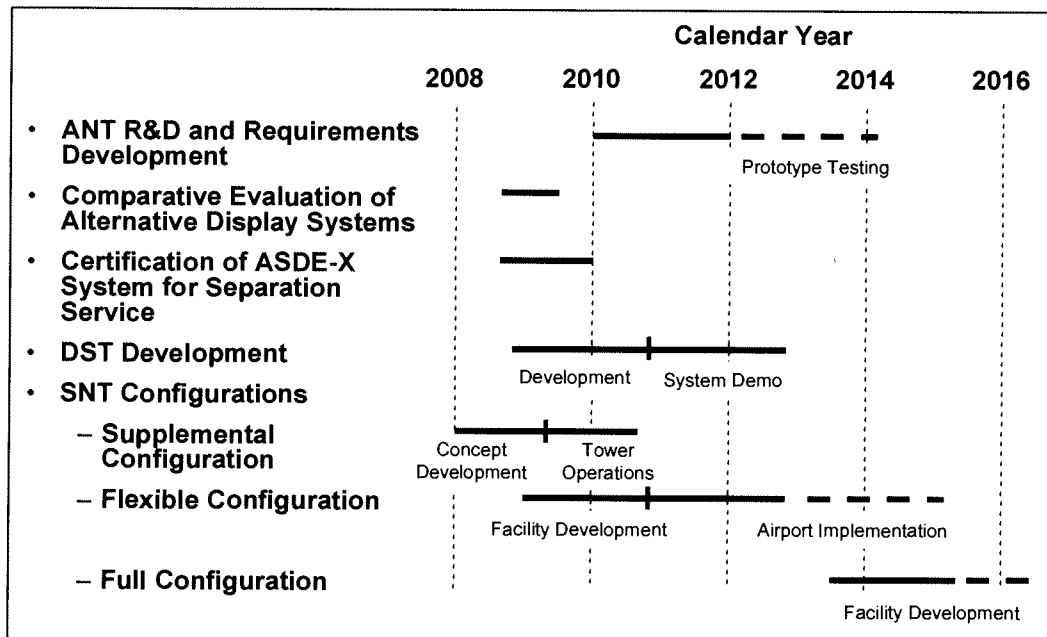
### **B.3 Full SNT Configuration**

With sufficient number of ATM personnel trained with the Flexible Configuration, SNT will now be implemented in Full Configuration. As illustrated in Figure C-3, the existing tower will now be decommissioned and the traffic will be fully controlled from the ground-level SNT facility. Depending on the volume and complexity of traffic the SNT configuration will have a combination of an integrated display, DST and/or data link capability.

A proposed schedule for SNT development is presented in Figure C-4. As previously explained, the early efforts will concentrate on evaluation and choice of a display system, certification of ASDE-X system for separation service, and the development of Flexible Operations capability; it also includes initial R&D activities related to ANT technology development. When the FAA decides to decommission existing low- and medium-end airport towers, an ANT/ SNT implementation plan will be developed.



**Figure B-3. Full SNT Configuration**



**Figure B-4. Transition towards Staffed NextGen Tower (SNT)**

#### **B.4 Training ATM Personnel for SNT Operations**

It has been mentioned earlier that implementation of SNT across the U.S. NAS involves a major shift in ATM paradigm. The present air traffic controllers are used to developing their situational awareness primarily by visual surveillance via OTW view from the tower cab; they also use other displays such as Automated Radar Terminal System (ARTS) Color Display and Standard Terminal Automation Replacement system (STARS) Lite Display. When providing ATM services from an SNT, however, the controllers have no such OTW view and they must obtain the situational awareness exclusively from the SNT display of surveillance data. This major shift from visual to sensor surveillance will be possible if and only if the controller community can build confidence in such displays and trust the situational awareness resulting from such displays. Consequently, controller training will be a very important element of the transition to the NextGen Towers.

The training of controllers should follow the established FAA framework and guidelines after the knowledge, skills and ability (KSA) requirements for SNT controllers are identified. However, in view of the basic paradigm shift in operations, it is suggested here that the training program should also contain the following elements:

(a) Familiarization with SNT Display

The SNT Display described earlier will be very different from and quite advanced compared to the present BRITE displays used in the tower cabs. These displays should first be introduced in a tower that is scheduled to transition to an SNT facility. Use of SNT display for a few months of tower operations will give the controllers sufficient familiarity and confidence in the efficacy of these displays. This operation will be similar to the operation of Display-Only SNT configuration or Supplemental operation from a tower.

(b) Airport Simulation at an Operational Test Facility

The airport operations should be simulated at some test facility and the controllers should control the traffic both with the conventional simulated window view and with the SNT system to be implemented at the airport. The controllers, being very familiar with the traffic patterns at their airport, will quickly build the confidence in the SNT system as they compare the two types of simulated operations.

#### **B.5 Selection of Airports for SNT Application**

It has been mentioned earlier in this appendix that most presently towered airports may be potential candidates for SNT application. These candidate airports can be divided into the following three categories:

- There are a number of airports that need new tower construction or refurbishment. FAA estimates that within the next 10-15 years FAA will need to spend over \$700M for construction at these airport towers. FAA should be able to avoid some of these costs with the application of SNT technologies in the various configurations described earlier.
- There are a number of hub airports that will benefit if some of their traffic can be rescheduled to fly in and out of nearby satellite airports. However, many of these satellite airports lack adequate physical and ATM infrastructures to be able to support

increased traffic levels. Although physical infrastructure improvements may be expensive for these airports, one can significantly improve the capacity of a number of these airports with secondary surface surveillance and SNT Displays. It may not be possible to reschedule all types of aircraft from the hub to satellite airport; however, enough traffic could be so rescheduled resulting in reduced delays at the hub airports.

- FAA is planning realignment of TRACON facilities in the near future. A number of TRACONs are presently collocated with tower facilities. If the TRACON is moved out of the tower during such realignment, one can conceivably discontinue the use of the tower and provide services from some ground-based SNT facility. Such an application will potentially save on operating cost and the cost of future tower replacement.
- NextGen envisions geo-independent General Service Delivery Points (GSDPs) that are designed and located appropriately for reducing the overall cost of service delivery. The total number of GSDPs is expected to be lower than the number of present service delivery points (ARTCC, TRACON, and ATCT); as a result, the cost of service delivery is expected to be much lower than that today. Conceptually, some of the GSDPs could be NextGen Towers (Automated and Staffed).

It will require a site-by-site examination of airports and TRACON facilities to develop a credible schedule of SNT implementation at these candidate airports. Each application must then undergo a rigorous cost-benefit analysis before taking any investment decision.

## Glossary

<b>2-D</b>	Two-dimensional
<b>3-D</b>	Three-dimensional
<b>4-D</b>	Four-dimensional
<b>ACARS</b>	Aircraft Communications Addressing and Reporting System
<b>ADD</b>	Aircraft-derived Data
<b>ADS-B</b>	Automatic Dependent Surveillance – Broadcast Mode
<b>AFSS</b>	Automated Flight Service Station
<b>AFTIL</b>	Airport Facilities Tower Integration Laboratory
<b>AMASS</b>	Airport Movement Area Safety System
<b>ANT</b>	Automated NextGen Tower
<b>AOPA</b>	Aircraft Owners and Pilots Organization
<b>ARTCC</b>	Air Route Traffic Control Center
<b>ARTS</b>	Automated Radar Terminal System
<b>ASDE-3</b>	Airport Surface Detection Equipment, Version 3
<b>ASDE-X</b>	Airport Surface Detection Equipment, Model X
<b>ASMGCS</b>	Advanced Surface Movement Guidance Control System
<b>ASOS</b>	Automated Surface Observing System
<b>ATC</b>	Air Traffic Control
<b>ATCSCC</b>	Air Traffic Control System Command Center
<b>ATCT</b>	Airport Traffic Control Tower
<b>ATIS</b>	Automated Terminal Information System
<b>ATL</b>	Hartsfield-Jackson Atlanta International Airport
<b>ATM</b>	Air Traffic Management
<b>AWOS</b>	Automated Weather Observing System
<b>CA</b>	Conflict Alert
<b>CAT</b>	Category
<b>CDTI</b>	Cockpit Display of Traffic Information
<b>CHI</b>	Computer-Human Interface
<b>D-ATIS</b>	Digital-Automated terminal Information System

<b>DLR</b>	Deutsches Zentrum für Luft- und Raumfahrt
<b>DSS</b>	Decision Support System
<b>DST</b>	Decision Support Tool
<b>DUAT</b>	Digital User Access Terminal
<b>EFB</b>	Electronic Flight Bag
<b>EFS</b>	Electronic Flight Strip
<b>FAA</b>	Federal Aviation Administration
<b>FDIO</b>	Flight Data Input/Output
<b>FDM</b>	Flight Data Manager
<b>FMCS</b>	Frequency Modulated Continuous Wave
<b>FMCW</b>	Frequency modulated continuous wave
<b>FMS</b>	Flight Management System
<b>FOC</b>	Flight Operation Center
<b>FOD</b>	Foreign Objects and Debris
<b>FSS</b>	Flight Service Stations
<b>GA</b>	General Aviation
<b>GSDP</b>	General Service Delivery Point
<b>gTCAS</b>	Ground-based TCAS
<b>ICAO</b>	International Civil Aviation Organization
<b>ID</b>	Identification
<b>IFR</b>	Instrument Flight Rules
<b>ILS</b>	Instrument Landing System
<b>IMC</b>	Instrument Meteorological Conditions
<b>JPDO</b>	Joint Planning and Development Office
<b>LAHSO</b>	Land and Hold Short Operations
<b>LLWAS</b>	Low-Level Wind Shear Alert System
<b>MLAT</b>	Multilateration
<b>MR</b>	Magneto-Resistance
<b>MSAW</b>	Minimum Safe Altitude Warning
<b>MSL</b>	Mean Sea Level
<b>MWS</b>	Millimeter Wave Sensor
<b>NAS</b>	National Airspace System

<b>NEXRAD</b>	Next Generation Weather Radar
<b>NextGen</b>	Next Generation Air Transportation System
<b>NNEW</b>	NextGen Net-Enabled Weather
<b>NOAA</b>	National Oceanic and Atmospheric Administration
<b>NOTAM</b>	Notices to Airmen
<b>NPRM</b>	Notice of Proposed Rulemaking
<b>OEP</b>	Operational Evolution Partnership
<b>ORD</b>	Chicago O'Hare International Airport
<b>OTW</b>	Out-the-Window
<b>PDC</b>	Pre-Departure Clearance
<b>PTZ</b>	Pan Tilt and Zoom
<b>SAS</b>	Single Authoritative Source
<b>SDP</b>	Service Delivery Points
<b>SNT</b>	Staffed NextGen Tower
<b>SUA</b>	Special Use Airspace
<b>SWIM</b>	System-Wide Information Management
<b>TCAS</b>	Traffic Collision Avoidance System
<b>TDOA</b>	Time Difference of Arrival
<b>TDWR</b>	Terminal Doppler Weather Radar
<b>TIDS</b>	Tower Information Display System
<b>TIS-B</b>	Traffic Information Service-Broadcast Mode
<b>TMI</b>	Traffic Management Initiative
<b>TODDS</b>	Tower Operations Digital Data System
<b>TRACON</b>	Terminal Radar Approach Control
<b>U.S.</b>	United States
<b>UAT</b>	Universal Access Transceiver
<b>VDL</b>	VHF Data Link
<b>VHF</b>	Very High Frequency